Astrophysical Journal, Supplement Series 2020 vol.248 N2

Unraveling the Complex Behavior of Mrk 421 with Simultaneous X-Ray and VHE Observations during an Extreme Flaring Activity in 2013 April

magic Collaboration , Other Groups , Acciari V.A., Ansoldi S., Antonelli L.A., Engels A.A., Baack D., Babić A., Banerjee B., De Almeida U.B., Barrio J.A., González J.B., Bednarek W., Bellizzi L.K., Bernardini E., Berti A., Besenrieder J., Bhattacharyya W., Bigongiari C., Biland A., Blanch O., Bonnoli G., Bošnjak , Busetto G., Carosi R., Ceribella G., Cerruti M., Chai Y., Chilingarian A., Cikota S., Colak S.M., Colin U., Colombo E., Contreras J.L., Cortina J., Covino S., D'Elia V., Vela P.D., Dazzi F., Angelis A.D., Lotto B.D., Puppo F.D., Delfino M., Delgado J., Depaoli D., Pierro F.D., Venere L.D., Souto Espiñeira E.D., Prester D.D., Donini A., Dorner D., Doro M., Elsaesser D., Ramazani V.F., Fattorini A., Ferrara G., Foffano L., Fonseca M.V., Font L., Fruck C., Fukami S., López R.J.G., Garczarczyk M., Gasparyan S., Gaug M., Giglietto N., Giordano F., Gliwny P., Godinović N., Green D., Hadasch D., Hahn A., Hassan T., Herrera J., Hoang J., Hrupec D., Hütten M., Inada T., Inoue S., Ishio K., Iwamura Y., Jouvin L., Kajiwara Y., Kerszberg D., Kobayashi Y., Kubo H., Kushida J., Lamastra A., Lelas D., Leone F., Lindfors E., Lombardi S., Longo F., López M., López-Coto R., López-Oramas A., Loporchio S., De Oliveira Fraga B.M., Maggio C., Majumdar P.
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Abstract

© 2020. The American Astronomical Society. All rights reserved. We report on a multiband variability and correlation study of the TeV blazar Mrk 421 during an exceptional flaring activity observed from 2013 April 11 to 19. The study uses, among others, data from GLAST-AGILE Support Program (GASP) of the Whole Earth Blazar Telescope (WEBT), Swift, Nuclear Spectroscopic Telescope Array (NuSTAR), Fermi Large Area Telescope, Very Energetic Radiation Imaging Telescope Array System (VERITAS), and Major Atmospheric Gamma Imaging Cherenkov (MAGIC). The large blazar activity and the 43 hr of simultaneous NuSTAR and MAGIC/VERITAS observations permitted variability studies on 15 minute time bins over three X-ray bands (3-7 keV, 7-30 keV, and 30-80 keV) and three very-high-energy (VHE; >0.1 TeV) gamma-ray bands (0.2-0.4 TeV, 0.4-0.8 TeV, and >0.8 TeV). We detected substantial flux variations on multi-hour and sub-hour timescales in all of the X-ray and VHE gamma-ray bands. The characteristics of the sub-hour flux variations are essentially energy independent, while the multi-hour flux variations can have a strong dependence on the energy of the X-rays and the VHE gamma-rays. The three VHE bands and the three X-ray bands are positively correlated with no time lag, but the strength and characteristics of the correlation change substantially over time and across energy bands. Our findings favor multi-zone scenarios for explaining the achromatic/chromatic variability of the fast/slow components of the light curves, as well as the changes in the flux-flux correlation on day-long timescales. We interpret these results within a magnetic reconnection scenario, where the multi-hour flux variations are dominated by the combined emission from various plasmoids of different sizes and velocities, while the sub-hour flux variations are dominated by the emission from a single small plasmoid moving across the magnetic reconnection layer.

http://dx.doi.org/10.3847/1538-4365/ab89b5

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